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Controlled Compliance Haptic Interface Using Electro-rheological Fluids

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ABSTRACT

Electro-rheological fluids (ERFs) are electroactive fluids that experience dramatic changes in rheological properties, such as viscosity, in the presence of an electric field. The fluids are made from suspensions of an insulating base fluid and particles on the order of one tenth to one hundred microns in size. In the presence of an electric field, the particles, due to an induced dipole moment, will form chains along the field lines. This induced structure changes the ERF's viscosity, yield stress, and other properties, allowing the ERF to change consistency from that of a liquid to something that is viscoelastic, such as a gel, with response times to changes in electric fields on the order of milliseconds. Control over a fluid's rheological properties offers the promise of new possibilities in engineering for actuation and control of mechanical motion. Devices designed to utilize ERFs include shock absorbers, active dampers, clutches, adaptive gripping devices, and variable flow pumps. The application of ERFs in robotic and haptic systems has been very limited. They have mainly been used as active dampers for vibration suppression and as tactile arrays for developing Braille systems for the blind.

In this paper a novel haptic interface is presented to enable human-operators to "feel" and intuitively mirror the compliance at remote/virtual sites enabling control of robots as human-surrogates. Haptic interfaces are intended to provide human operators intuitive feeling of the stiffness at remote or virtual sites in support of space, medical, military and underwater robots. In this paper, the modeling and experimental studies of electrorheological fluid (ERF) based haptic interface are presented. Forces applied at a robot end-effector due to a compliant environment are reflected to the remote human operator using an ERF based haptic interface where a change in the system viscosity occurs proportionally to the force to be transmitted. Results of preliminary tests will be presented where forces, displacements, pressure and temperature data are measured and analyzed.